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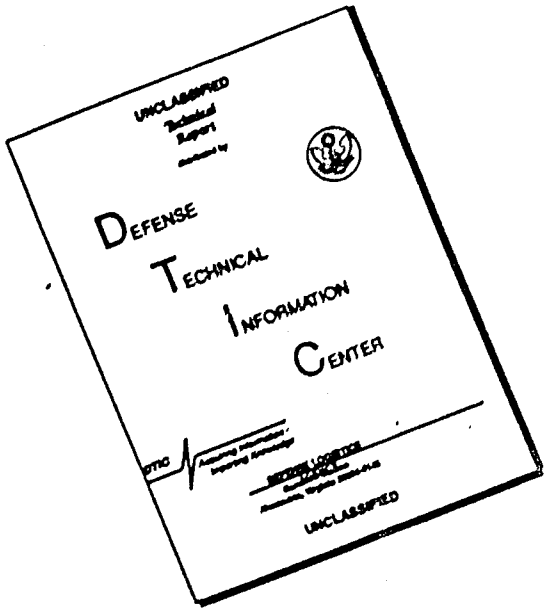

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RESEARCH MEMORANDUM

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RESEARCH MEMORANDUM

A DATA PROCESSING CONCEPT FOR AIR FORCE BASES

J. A. Postley
S. L. Pollack

RM-2232

5 September 1958

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PREFACE

Dispersal of Air Force installations is increasing greatly the number of units requiring data processing. It also tends to diminish the technical capability of each unit to handle this task. Centralized and largely automatic data processing systems, as outlined in this report, seem to be a desirable answer to this problem. The equipment needed for such systems is now available or becoming available. Its application to Air Force materiel needs can be achieved within the next few years.

This report discusses the broad concepts of automatic input and processing of data, and explains their importance to expeditious managerial control. Many detailed aspects of these concepts are under study in order to devise methods for their implementation.

SUMMARY

The past ten years have seen very substantial advances in the development of electronic data processing equipment (EDPE). These advances have opened up enormous possibilities for fast, efficient, managerial control of large organizations, including the Air Force logistics system. On the other hand, serious problems peculiar to EDPE have cropped up along with the advances; for one thing, so many kinds of equipment have been devised for so many different purposes that any attempt to organize an integrated data processing system is in danger of getting lost in a forest of bewildering complexity and overlapping functions. When we consider, moreover, the high cost of EDPE and the consequent penalties of inadequate system organization, we can see that if the potential benefits from EDPE are to be obtained it will be necessary to develop a comprehensive plan for data processing. This Research Memorandum undertakes just such a task for Air Force bases.

Individual Air Force bases have recently employed EDPE to great advantage, but are beginning to feel the impact of the problems of cost and organizational complexity. To help solve these problems, this report attempts to delineate the characteristics of an optimum posture for base data processing, and to crystallize these desired characteristics into a specific plan. Parts of this plan can be implemented as early as 1962. The terminus of the study is 1965, beyond which accurate estimates are difficult. The major findings of this study are that:

(1) Improved techniques and equipment for initial data input and automatic retranscription are needed for use at all bases and in each functional area.

(2) To the extent that it is employed, automatic data processing should be integrated to reflect in each of the functions with which it deals (e.g., supply, maintenance, personnel, finance) the relevant events in others. To this end, it should be carried out by new organizations established for the purpose at several points in the Zone of Interior.

(3) The data processing operations of input and processing must be carried out by trained specialists.

(4) Present periodic historical reports can be reduced in number and size, and replaced by concise summaries of pertinent information for all levels of command and management.

To accomplish these desired ends, this study outlines a posture for base data processing, which would comprise:

(A) Base Information Centers (BIC's) in the continental United States. Each of these centers would be equipped to maintain the records (e.g., personnel, supply, and financial) for about 20 to 40 bases, and to act as a readily accessible information repository for much of the data pertaining to base operations. Such centers would therefore be in a position efficiently to carry out the functional integration which is a fundamental objective of this concept.

(B) Equipment at each Air Force base to translate data into a form which can be dealt with automatically, to retranscribe automatically information so captured for further use, and to present automatically the results of processing for decision-making at all the appropriate management levels.

(C) An efficient system for accomplishing those subsidiary data processing functions which are truly local to a base, involve subjective considerations, or are otherwise more suitable for on-base handling.

(D) A positive continuing program for carrying out the training required by the widespread use of automatic equipment and new techniques in this program.

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I. INTRODUCTION

THE PROBLEM

One of the outstanding technical phenomena of the past decade has been the far-reaching series of developments in electronic data processing equipment (EDPE). Growing rapidly in size, complexity, capability -- and cost -- this equipment has progressed from its early employment in lengthy and intricate mathematical calculations for scientific purposes, through a further stage of widespread application to large-scale clerical problems in business and elsewhere, to its present stage, wherein it is possible to use EDPE as a tool in the managerial control of large organizations. Until the presently known electronic data processing equipment and techniques were evolved, it was impractical to integrate all the various air base data processing functions into a single unit. The Air Force, whose managerial control problems are similar in many respects to those of a large business, has been quick to realize the advantages to be reaped from the new technology.

The rapidity of EDPE's growth, its high cost, and the multifarious purposes for which it has been designed, have of course given rise to peculiar problems of their own. Individual Air Force bases, for example, have recently employed EDPE advantageously, but the acquisition of more and more equipment as time passes is a costly affair. Data processing functions and their resultant reports often duplicate each other unnecessarily, money and man-hours are not always expended to their full advantage, and the sheer increasing complexity of the system makes competent management more difficult.

Increasing acceptance of the concepts of dispersal and mobility in both the missile and the manned aircraft forces complicates the task of processing data on behalf of these organizations. Also, the expectation of operating units ever smaller in size and scope increases the problem of having each react in the light of considerations of the system as a whole.

THE APPROACH: LONG RANGE PLANNING

The present study does not look for short-term, piecemeal solutions of Air Force data processing problems. It seeks to provide the Air Force with an advantageous position at the end of a long (e.g., five-year) time period and thereafter. Less comprehensive, short-term solutions often fail to deal adequately with the total problem of data processing and, at the same time, they divert much-needed resources from this essential task.

We realize fully that help is badly needed by those who are charged with the short-range solution of present Air Force base data processing problems. These problems are important and difficult to solve, but their solution must not be permitted to prevent solution of the larger problem.

Our purpose here is to establish a goal toward which interim solutions can and should be directed. In so doing, we wish to provide a standard against which data processing programs, both long- and short-range, can be measured. This intent is supplementary to our primary goal of helping to obtain an optimum data processing posture for Air Force bases.[1]

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[1]Subsequent studies on this subject will deal with various aspects of this posture in more detail. We recognize that specification of the concept herein described suggests a myriad of related problems, many of which will be considered in these forthcoming studies.

GENERAL REQUIREMENTS

The problem of data processing for Air Force bases may be described in three parts:

(1) Techniques, and equipment (where necessary), must be developed to insure that the data entering the system, and on which any results are based, are timely and accurate. Realization of this objective will require a major increase in emphasis, in terms of dollar and personnel resources, over the present level.

(2) The equipment and techniques utilized must exploit the most efficient computers, communications equipment, and other products of coming technology.

(3) The future system must relate data processing outputs to management objectives far more closely than at present. Present reporting systems have been perpetuated in the face of changing management requirements and processing capabilities.

TIME PERIOD

The system described in this paper, or at least most of its phases, can be implemented as early as 1962. We have not carried our thinking in this study beyond 1965, so it has not been necessary to consider computers, weapons, and organizations entering the system at a later date. Estimates relating to these factors through 1965 are probably accurate enough here, but fall off rapidly thereafter. For these reasons we describe the period under study as "1962 - 1965." Delays and difficulties might well push realization of the proposed system out farther than 1965. On the other hand, immediate start of planning and development could lead to realization of gains in important segments of the Air Force at an earlier date.

II. DEFINITION OF DATA PROCESSING

Since the term "data processing" currently has a large number of usages, it is probably well at this point to explain its specialized use in the present context. By defining the term here in one particular way, we do not mean to suggest that other usages in different contexts are wrong, but rather that the one used is the most pertinent to this discussion.

Data processing can be said to consist of three phases: generation of the data and their introduction into the system, information evaluation or interpretation (processing), and result presentation. Phase one comprises collecting the information (data) necessary to reflect events which have taken place, and preparing and transmitting it in a form suitable for use in the second phase. Phase two comprises manipulating data according to logical or mathematical rules provided exogenously so that specified analysis of the data can be made, and also provides for making prespecified logical decisions on that basis. Phase three comprises the presentation of outputs resulting from the processing phase of the cycle for the information and action of the people concerned.

The three phases may be outlined as shown below:

I. Data generation and introduction into the system

   A. Static data -- data reflecting the relevant policies and circumstances.

   B. Dynamic data -- data which reflect the events which take place.

II. Information evaluation or interpretation (processing)

   A. Summarizing and organizing data

   B. Detecting discrepancies from plan

   C. Executing management rules

III. Result presentation for

A. Operating decisions

B. Planning decisions

C. Legal requirements

As the outline indicates, there are really two kinds of data with which any data processing system must deal: static and dynamic. Since this phase is necessarily basic to the implementation of further data processing, it will be profitable to examine it further.

Static data (or, more properly, relatively static data) include data which define the problem, such as the priority system employed, the mission category of Air Force bases, the maintenance skills available at each location, a listing of events which constitute a noteworthy change in readiness, the AFSC's and proficiencies of base personnel, price of items, ERC code, data on whether an item is base- or depot-reparable, warhead size (for operations planning), designation of the office of primary responsibility for each decision, etc. This type of data is, or should be, provided as a basis for the design of a data processing system which, then, becomes the means of translating these data into a working air base logistics data processing system. Static data are the data of which the basic files of the system are composed.

Dynamic data report events to the data processing system. While some of these data must be routed through the system as soon as they are known, other events, although noted at once, need not be reflected immediately as usable data. The purpose of this activity is to represent events in a form which can be utilized in the remainder of the data processing cycle. By this standard, copying information from one written form onto another may not

actually constitute the introduction of data into the system whenever the data so copied are no more usable in the second form than in the first. When EDPE is employed for processing data, those data must be transformed into "machine language" before they are of any use to the machines. This may be done by various forms of instrumentation (automatic transaction recording, automatic checkout equipment, automatic communications network monitoring, etc.) or by manual retranscription of the data into machine-readable form (punched card, punched tape, or magnetic tape preparation with keyboard entry).

On the basis of the data introduced as above, this information can be evaluated and interpreted (processed) in phase two. This operation includes summarizing and organizing dynamic data, detecting discrepancies from planned performance, and executing management rules. Activity of this kind done manually (even on a very small scale) is data processing, and its performance may be most important. When this processing is sufficiently large in volume or difficulty, it may be accomplished by an organization established for the purpose (an organization which does not normally generate its own data but processes the data generated by another organization and returns the results to them) and may be carried out manually or by machine. Thus the preparation of supply requirements, budgets, stock balance and consumption reports, payrolls, accounting, flight proficiency reports, squadron readiness summaries, etc., is suitable for accomplishment by such an organization in most cases; while maintenance of bench stock balances, lunch hour schedules, and aircraft locations on the landing strips or aprons is not. Let us note that the data processing with which we are dealing in this paper does not encompass such activities as ground control

of aircraft, of missiles in flight, ground controlled intercept, computer interpretation of radar input data, etc.

The third phase of the data processing cycle, result presentation, is also divided into two parts: presentation of results so that operating decisions can be made, and so that planning decisions can be made. The achievement of rational decisions based on timely, accurate information is, of course, the objective of the data processing system. Therefore it is clear that, while the achievement of objectives is the third phase of operation of any data processing system, specification of objectives is necessarily the first step in the design.

In planning for result presentation it is essential to distinguish between outputs for operating and those for planning purposes. Operating decisions are likely to be the immediate cause of events, which in turn generate data and feed them into the cycle. An example of an operating decision which can be made automatically is the decision to resupply a spare part, based on the recognition of the fact that reported issues have reduced the balance on hand to or below the reorder point, and, therefore, a resupply sufficient to bring the stock balance back to the stock control level is now indicated. On the other hand, immediate management action may be required to dispatch a special shipment of this spare in those cases where an AOCP can thereby be avoided.

Planning decisions are usually subject to less immediacy than operating decisions and are almost invariably made by management people rather than automatically. They are most effective when they are based on results of processing data which indicate what the plan has been and how events which are actually taking place compare with this plan. To know that 100

man-hours of maintenance effort were expended during a particular time period is of little use unless the amount that was planned, together with that which was actually available, is also known. This important phase of data processing must be carefully designed so that the information provided is, as nearly as possible, exactly sufficient to achieve the decisions for which it is intended.

III. A SYSTEMS APPROACH TO BASE DATA PROCESSING

The characteristics of modern large-scale EDPE, such as speed, flexibility, reliability, and automatic control now enable us to deal much more effectively with complex data processing problems of Air Force bases. For this reason, it is more important than ever for management to take a "systems approach" to the role and organization of base data processing. Objectives for the data processing system must first be defined. Within this framework, the patchwork method of dealing with one problem or one functional area at a time (e.g., inventory control, personnel, finance, maintenance, operations, etc.), of looking at one area of base data processing in isolation from other areas and problems, cannot take into account the interactions involved. The failure first to establish system objectives and then to consider the interrelationship of base, depot, and weapon system management within them, will result in a data processing system which does not yield the most effective results.

In this study we will consider the total ZI base complex as a system, and study the interrelationships of the various functional areas that are found on a base and throughout the base complex, since by very definition a system involves the interaction or interdependence of elements in a coherent whole. We should look at the inputs, outputs, processings, etc., in the light of these interactions as well as the data processing requirements of the base and the higher command echelons. The various functional areas such as personnel, supply, maintenance, finance, operations, etc., should be viewed as components of an over-all activity and not as separate, independent parts.

Viewed as a whole, the problem of data processing for Air Force bases is very complex. Data generated within supply are useful in maintenance and finance; data generated within operations are required in personnel and finance; and data generated at the base are required at the depot and at the major command headquarters. By looking at the problem as an entity, we may be able to eliminate duplication of effort within these functional and geographical organizations and, furthermore, to provide a more nearly complete picture with inputs designed to produce desired results. Only from such a picture can we develop an efficient data processing system.

DATA PROCESSING AS A CATALYST AMONG FUNCTIONS

The purpose of data processing should be to achieve the objectives of the various functional areas in the Air Force, (e.g., operations, maintenance, supply, finance, and personnel), being bound only by the objectives of those functions, in terms of pertinence and timeliness, and not by their present organization.

Since information needed in one functional area is often generated in another, a desirable approach to the data processing problem is to strive for integration of the data processing related to these functions, but not necessarily for the corresponding integration of management. It is highly desirable that logistics management reflect the interactions which do exist between functions. This concept is difficult to achieve in any current environment, however, since existing organization is usually by individual function; hence the design of any new data processing system is likely to be so influenced.

Until the recent advent of large-scale data processing equipment and associated techniques, it has been impossible to build any significant degree of functional integration into the related data processing systems. This is true since the resultant single operation would have been too large and complex to be dealt with as a single unit.

As a result of this situation, many echelons of sub-organization have been built up within the Air Force in the data processing field, each largely independent of every other both laterally and, in some cases, even vertically. As a further consequence, functional interaction has been lacking and duplication of the data processing effort at several echelons of organization has become the rule rather than the exception. The duplication of personnel information in personnel, operations, supply, and maintenance is a case in point. Such duplication is quite common, not only at different levels of command organization, but even on a single Air Force base. Many elements of supply information are likewise repeated at the spare parts depot, at the base, and even at the wing or squadron.

EQUIPMENT CONSIDERATIONS

The recent advances in electronic data processing equipment have been startling. Beginning only ten years ago, the use of EDPE in government and industry has grown very rapidly. Although at the start all the applications of EDPE were "scientific" (mathematical, for example), applications to the large-volume clerical problems of business organizations were developed as early as 1953, and extensions into the field of scientific management are currently in process.

There have been several reasons for this rapid growth. They can be summarized by the statement that the speed of EDPE since its development ten years ago has increased rapidly, while the cost for a given data processing job has correspondingly decreased.

Data processing capabilities of medium-scale computers are, by definition, substantially less than those of large-scale machines; and small-scale electronic computing devices are correspondingly less capable than the medium-scale ones. Since the notion of large-, medium-, and small-scale computers is not precise, we shall consider them here in this sense: a small-scale computer has sufficient capability to accomplish some but not all of the data processing job for a single Air Force base; a medium-scale computer has sufficient capability to accomplish, and thereby integrate, substantially all of the data processing job at a single Air Force base; and a large-scale computer possesses the capability to carry out substantially all of the data processing jobs for a dozen or more large Air Force bases.

Large-, medium-, and small-scale computers can also be categorized by the relative sizes of their basic rental costs. The large scale systems usually range from $30,000 to $60,000 per month (although some are considerably higher), the medium-scale from $15,000 to $30,000 per month, and the small-scale from $3,000 to $10,000 per month basic rental. According to this categorization, the costs are in a ratio of about 6:3:1.

To the extent that computers are required at all, the question of the least rental cost of EDPE in the Air Force base complex can be raised. A system in which computers are not properly distributed will place the Air

Force in an unfavorable rental position.[1] For example, if five medium-scale computers are utilized to accomplish work which could be carried out by a single large-scale computer, the rental costs could be reduced by employing the large-scale machine given the above cost ratio.

CENTRALIZED DATA PROCESSING

On the basis of cost and workload considerations, it seems evident that economies can be achieved by the use of large-scale data processing techniques and equipment in several Air Force situations. With base data processing, however, it is also true that very few large-scale problems, if any, can be developed if they remain segregated by subfunction at base as they are at present. In such an environment, there is simply not enough data processing load in each subfunction to permit the full utilization of a large-scale data processing machine to which the above-mentioned advantages accrue.

This state of affairs, then, allows us to conclude that some degree of centralization is required if we are to achieve potential cost and capacity advantages. At most Air Force bases, this centralization of much of the data processing load at a single point has already been achieved or planned for. As a result, large bases are able to employ most of the capacity of a medium-scale data processing machine. On the smaller bases, a medium-scale machine cannot be efficiently utilized and hence small-scale data processors or punched-card accounting machines must be employed.

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[1] Obviously a rigorous comparison would involve total costs. As a first approximation, it is assumed that total costs are proportional to the rental costs involved.

But even where medium-scale equipment can be efficiently utilized, the advantages gained in terms of processing capacity and its cost are so short of those available with large-scale equipment as to suggest further centralization. Where small-scale equipment must still be used, this suggestion is of course even stronger.

These facts, then, indicate that while some data processing activities must continue to be carried out at the base, it is highly desirable to centralize at a single geographical point as many as possible of the data processing jobs of several Air Force bases.[1] Such centralization will burden the postal and electrical communications facilities with a load far exceeding the present one; however, the very great advances in the potential capability of electrical communications facilities by the period 1962-1965 will be more than equal to the resultant transmission load. Further, it seems certain that the cost of electrical communications during that time period, while far exceeding the present annual cost, will itself be far outweighed by the cost advantages accruing from the use of large-scale computers.

The objectives of a system based on the concept of geographical centralization of data processing for bases and the automatic input of relevant data are to:

1. Relieve the bases of the job of automatic processing of data, to the extent possible, thus enabling them to concentrate on their primary mission of flying and maintaining aircraft and missiles;

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[1] While it is presently impossible for us to estimate the total percentage of base manpower engaged in data processing of one kind or another, this number may be as high as one-fourth of the total base manpower. If 50 per cent of this activity can be mechanized, as much as 10 per cent of the activities of an Air Force base can then be performed automatically.

2. Decrease the total cost of data processing to the Air Force by exploiting the efficiency of large-scale EDPE and reorient the organizational structure accordingly;

3. Increase the efficiency of data processing on each base by integrating the data processing of its various functions;

4. Improve the quality of input data generated at the base;

5. Achieve closer liaison between Air Force organizations and their major commands; i.e., achieve the actual capability to implement the systems outlined by manual and directive; and

6. Provide information to all levels of management as needed.

It is the intent of this paper to show that these objectives can best be achieved by:

A. A substantial increase in the automaticity with which pertinent data is collected at its source and entered into the system;

B. Utilization of the potential for automatic information storage and retrieval and processing of data, which will be available in the time period 1962-1965;

C. Functional integration and centralization of automatic information storage and processing of data, whereby the necessary data processing skills and management control can be brought to bear and costs minimized;

D. An increase in on-base and off-base electrical communications capacity adequate for easy and rapid flow of information from the sources of data to the processing center and from the processing center to the users of results, the cost of which can easily be offset by the direct and indirect savings mentioned above; and

E. A much closer relationship between outputs from the data processing phase and the decisions made from them. This will decrease the number and size of periodic historical reports and increase the facility to produce situation summaries of these records (which are retained within the machine system), upon request of the appropriate management at the base or elsewhere.

There is general agreement that functionally or geographically centralized data processing systems are preferable to decentralized ones.[1] In the specific case of base data processing disagreement arises as to where this centralization is to occur.

It should be made clear that this study's emphasis on centralized data processing is separate and distinct from the issue of centralized management. Any effective management system, centralized or decentralized, should be supported by the most effective system possible for data processing. This study strongly indicates that the system which will most effectively achieve the objectives stated above is one whose input phase is highly mechanized, whose evaluation and interpretation phase (including the storage of the related information) is functionally and remotely centralized, and whose output phase is oriented to the decisions which must be made.

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[1] AFM 171-9, Management of Data Processing Equipment, dated 1 June 1958, states, "Major data processing systems will be centrally located and managed to provide common support of functions where practicable. This is an approved Air Force concept based on the facility for integration of data as well as economy."

IV. DATA GENERATION AND INTRODUCTION INTO THE SYSTEM

The results produced by EDPE can be no better than the source data. While the need to check data prior to their use by Punched Card Accounting Machines (PCAM) or EDPE has long been recognized,[1] the more immediate and worthwhile project of insuring that data are correctly recorded at the start has too long been ignored. In an automatic data processing system, with data generated in an operation distinct from the processing phase, new techniques of data recording must be developed. Since our objectives include minimizing the number of errors entering the system, the guiding principles of this new technique must be that (1) the number of transcriptions of data shall be held to a minimum, and (2) data recording shall be done with minimum human intervention.

The base is necessarily the organization at which much of the data entering the system is generated. It has been relying on mechanized recordkeeping to perform its clerical operations more rapidly, accurately, and cheaply than do people. It must now look to mechanization to help it solve the problem of introducing good input data into the data processing system.

HARDWARE FOR INPUT DATA RECORDING

Sometimes this problem can be solved by eliminating the human element during the actual data-generation phase. For example, several manufacturers are presently developing automatic checkout equipment that will provide appropriate information in a form suitable for EDPE. This technique is

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[1]For a fuller discussion, see S.L. Pollack, Electronic Data Processing Control of Air Force Spare Parts Inventories (U), The RAND Corporation, Research Memorandum RM-2013, November 14, 1957, Chapter I.

clearly applicable to certain supply and maintenance data for particular weapon systems.

But many data processing events must continue to involve human beings, the desirable goal then being to minimize the errors associated with human intervention. If cost were not a consideration, the ideal way to achieve this goal would be to have at the base an input device with a very large memory and a button for each possible event that could occur. When it did occur, the appropriate button would be pushed down and the data captured in machine language, on some such appropriate medium as magnetic tape, ready to be transmitted to and used by EDPE.

Although we are a long way from this ideal method, equipment manufacturers are headed in this direction. A prototype machine has been developed, for example, which reads magnetic cards and accepts information from a typewriter to create a transaction and place it onto a magnetic tape. To insure accuracy, the machine checks the item identification number typed by the human against the item identification number on the magnetic card that was chosen. Further, most of the static information presently written or punched by human operators is maintained on the magnetic card, thus reducing chance for error.

For those actions that occur frequently at a base, these special-purpose machines must be designed so as to require only the single manual operation of keying the identification number (for checking purposes). Issues of spare parts to organizations on a base appear to be voluminous enough to warrant such a machine. The magnetic card in this case would carry the appropriate posting code in addition to other static codes, such as cost, weight, and substitutes. The machine could be made to interpret a

piece of metal, similar to a dog tag, brought by the person requesting the part. The piece of metal could identify the organization and the aircraft for which the part is needed.

We present a few more examples of hardware developments that may be applicable to an automatic data processing system and are presently available or offer promise of being operational by the period of this study.

The National Bureau of Standards has completed FOSDIC II[1] (Film Optical Scanning Device for Input to Computers). This device is essentially an electronic scanner which reads filmed images of punched cards, searches this film for specified card information, and copies the selected information onto new cards for computer input. Each 100-foot roll contains up to 13,000 cards of information. The microfilm containing the information has these advantages:

1. Volume of file storage over that of punched cards can be reduced by a factor of over 100.

2. Duplicate files, when necessary, can be easily and economically prepared.

3. Visual inspection of the data content and condition of the file is readily available with a microfilm viewer.

4. Data can be preserved almost indefinitely.

A possible use for this equipment might be the storing of large volumes of static information that have to be referred to from time to time, such as historical data.

A scanning and display device[2] is also presently being developed by

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[1] See National Bureau of Standards Technical News Bulletin, May, 1957, Vol. 41, No. 5, for fuller discussion.

[2] See Proceedings of the Eastern Joint Computer Conference (IRE-AIEE-ACM), 1957, and National Bureau of Standards Technical News Bulletin, April, 1958, Vol. 42, No. 4, for fuller technical discussion.

the National Bureau of Standards, which will convert pictures into digital form suitable for input into computers, and display results as a visual output. It is hoped that the experience gained from this and similar devices will lead to the development of a device that will scan handscribed cards and convert the information into machine language for immediate computer use. The importance of eliminating retranscription of data cannot be overemphasized.

Two other scanning devices translate printing into punched cards. One scans a special plastic card bearing information stamped in raised letters, and the other scans documents that have been printed or typed with significantly located dots of special ink or carbon deposit, with the data encoded. Both can provide the machine-language input to a computer. These machines, too, are cited as examples of early efforts to provide the ability to convert handscribed data to machine language.

The above are some examples of the direction manufacturers must take to provide the potentiality for good source data. There are many others. The purpose of this section, however, has been to list several types of hardware which could be used for this purpose rather than to give a complete enumeration of them.

BASE INFORMATION FLOWS IN A CENTRALIZED DATA PROCESSING SYSTEM

It helps to think of the data processing center -- whether it be at a remote location or at the base -- as a "black box" whose purpose is to accept appropriate information from each of the management functions, such as maintenance, personnel, and supply, and interpret and evaluate that information for all functions to which it is applicable. The timeliness with which the information must be recorded and communicated to this black box is determined

by the purpose for which it is used. Not all data is required at the instant it is generated; efforts to provide it immediately may injure system effectiveness.

Consider the information on one unit's morning report needed on the same day by other units on the base -- e.g., the mess officer needs to know the total "head count" of personnel on duty. The black box can furnish this information to him if it can accept the daily change notice, process it, and transmit the required information to the mess officer quickly enough. Otherwise, the organization making up the change notice will have to prepare a separate head count for the mess officer by other means, in addition to sending the change notice to the black box for morning report preparation.

BASE RESPONSIBILITIES

In the future there will be increased automatic data processing. It will therefore be necessary for bases to concentrate their data processing efforts on producing highly accurate data in appropriate standard forms. This, combined with the input data control[1] performed by the data processing center, will provide a solid foundation for the data processing system, and will almost surely result in a greater mechanization in this area.

In addition to these input responsibilities, there exists a significant number of other activities which are within our definition of "data processing" and which must remain at the base. For, while it might be possible to do so, it does not seem desirable to attempt, for the foreseeable future, to centralize all base data processing activities.

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[1] See Pollack, op. cit.

The data processing operations which will remain at each base, even within a centralized system, might include: the maintenance of due-out files in Supply; specialist scheduling and dispatch, and work order control, in Maintenance; and maintenance of ready reference files in Personnel. These activities, and others not explicitly identified at this time, constitute the nucleus of a non-trivial set of operations which, in addition to the input operations described above, must be performed at the Air Force base. The local nature of these jobs, and their lack of impact across any aggregation of bases, combine to make their on-base accomplishment attractive.

V. EFFECTIVE USE OF EDP AND COMMUNICATION

This section discusses the data processing interrelations among the management functions at a base, proposes a system for integrating them, and describes their characteristics and communication needs. Alternative data processing postures within these systems are discussed.

BASE MANAGEMENT FUNCTIONS AND DATA PROCESSING

It is usual practice to assign management responsibility on a functional basis. The major management functional areas at most Air Force bases are:

1. Maintenance
2. Supply
3. Personnel
4. Financial Services
5. Operations and Training
6. Air Installations
7. General Administration
8. Manpower and Organization

While the functional delineation of this management structure is the foundation on which to build any data processing system, centralized or decentralized, there are two possible paths the data processing system analyst may follow: (1) he may list all the appropriate data processing functions required to accomplish each management function, duplicating where necessary, or (2) he may determine all possible data processing functions necessary to perform the total job without duplication, and then determine to which management functions each is appropriate.

As has been indicated previously, the latter, which we have called the "systems approach," is the better of the two when there are many interdependencies among the various management functions, as there are at Air Force bases. Table 1 lists some of the present base data processing functions and the management functions that are possibly affected by them.

Table 1

DATA PROCESSING FUNCTIONS

Function	Management Functions Possibly Affected[a]
Input data control	A
Man-hour accounting	A
Scheduling TOC, periodic and field maintenance	M, S, O
Stock Cataloging	M, S, F
Supply requirements, e.g., automatic requisitioning, stock level computation, excess item activity	M, S, F
Shipment control	M, S, F
Budget accounting	A
Flight scheduling	O, M
Personnel scheduling	P, and appropriate function
Payroll (civilian and military)	F, P
Base construction and maintenance	E, F
IAM and materiel accounting	F, S

[a] Abbreviations: A -- all management functions, E -- air installations, F -- finance, G -- general administration, M -- maintenance, O -- operations, P -- personnel, S -- supply.

To illustrate, consider the absence for a week of a mechanic whose AFSC is 4717. Personnel needs to know what kind of absence it is, e.g., sick leave, AWOL, or annual leave; Finance is primarily interested in whether it is authorized leave; and Maintenance may want to be informed if this skill is critical on that base. All these functions are affected, even though the original notice of his absence is sent to the personnel function via the morning report.

It is desirable to have an integrated data processing system which will furnish needed information expeditiously to all functions. We now discuss such a system.

THE BASE INFORMATION CENTER (BIC)

It is our thesis that mass data interpretation, evaluation and storage for bases should be accomplished by a set of base information centers (BIC's) in the ZI. The following discussion assumes that each BIC will be the data processing focal point for all bases in its domain. A later section discusses the orientation of this domain by major operating command or by geographical region. While the posture which is desirable for missiles may differ in some details, the principles stated in this report apply, with very few exceptions, to missile and non-missile bases alike.

Major Data Processing Organizations in the BIC Era

This concept provides that the bulk of Air Force logistics data processing be done by the following organizations:

1. A Weapon System data processing center (DPC) for each of the major Weapon Systems -- where the supply balances of the weapons accounts at the various bases, and the balances of the weapon system storage sites will be maintained, with the weapon system assets under the control of the Logistics Support Manager. This manager will provide the necessary individual and consolidated reports to the appropriate commands and property class (or commodity) managers. (See Appendix A for information flow in a typical major weapon system.)

2. A data processing facility for each of the AMA's -- where supply balances for their depots will be maintained by property (or commodity) class. Data processing at the AMA is concerned primarily with depot inventory management to satisfy requisitions on the depot and to accomplish the requirements calculations for the various property (or commodity) classes under the control of that AMA. In addition, the AMA data processing facility

will compute the Master Repair Schedule. The BIC will be the link between bases and the AMA's.

3. A Base Information Center for each of several domains in the continental United States -- which will maintain the records (e.g., personnel, supply, and financial) for each of several aggregations of bases in its domain. It will be responsible for providing the necessary individual and consolidated reports to the appropriate commands and property class (or commodity) managers, as well as to management at the base. (See Appendix B for information flow.) The operation of each BIC will require the close cooperation of the various Air Force elements concerned. (See Appendix C for Base-Regional BIC Information Flow, and Appendix E for Base-Command BIC Information Flow.)

Characteristics of a BIC System

In order to give some feel for the resulting structure, we will consider a BIC system organized on a regional basis, with a BIC located at each of eight AMA's in the ZI. At the end of this chapter we discuss considerations relevant to determining the most advantageous centralized data processing posture, oriented by region or command.

1. Each BIC will service about 20 bases.
2. The expected daily transaction volume at each BIC for three of the major functions is:
   a. 30,000 - 40,000 supply transactions[1]
   b. 20,000 - 30,000 financial transactions
   c. 5,000 - 10,000 personnel transactions

[1] This assumes that major weapon systems are keeping their own supply records at their DPC and not at the BIC.

3. The expected volume of Master Records at each BIC for these functions is:

   a. 300,000 - 500,000 supply master records[1]

   b. 50,000 - 75,000 financial master records

   c. 100,000 - 125,000 personnel master records (ratio of military to civilian is approximately 3 to 1.)

These volumes, though large, are well within the capability of current large-scale computers. One such modern large-scale computer, renting for approximately twice as much as a so-called medium-scale machine, makes it possible to increase data processing capacity far in excess of this ratio.

The Use of Air Force Experience in Hardware Determination

It is apparent each BIC will require large-scale EDPE to perform its functions for the approximately 20 bases in its region. This study will utilize the following Air Force sources of information as an aid in determining the proper type and number of such EDPE with its associated non-electronic equipment:

1. OCAMA experience on the B-52/KC-135 weapon system,[2] which is operating under the ELECTRO LOGS concept;

2. SAAMA experience on a test of automatic resupply for ADC bases;

3. Monthly AFE6 reports which mechanized bases and bases using EDPE send to their commands;

4. Monthly Base Supply Reports (RCS-S1).

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[1] This also assumes that major weapon systems are keeping their own supply records at their DPC and not at the BIC.

[2] See S. Pollack, op.cit.

BASE-BIC COMMUNICATION

Whatever the procedures employed, a fundamental requirement of base data processing is to communicate data generated by the several base activities, from the point of generation to the point where it is summarized and processed, and thence to the point where the results are required for management decisions. In a base data processing posture which includes the concept of BIC's, the point where data is generated and the point where it is summarized and processed are rather far from each other; the concept does not significantly change the distance between the processing point and AMC or major command headquarters. Thus the BIC concept increases the problem of off-base data communication.

A study of the technology of communications equipment[1] reveals that a communication system which will meet the requirements of the BIC time period -- in terms of volume, timeliness, and accuracy -- is feasible. Further, this system would be equally as responsive as the on-base communication system which would be required if data summarization and processing were carried out primarily at the base level. The cost of such a data communication system will certainly be greater than that of a base-centralized system. However, improvements in the present logistics communications network are necessary in any case. The extent to which the improvements presently programmed are inadequate for a BIC type system--if at all--cannot be accurately judged at this time. In actuality, the additional cost of communications may therefore prove to be negligible. Whatever the cost involved, it can be evaluated only by comparing it to the dollar savings attainable through (1) proper

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[1] To be reported upon separately in a forthcoming paper.

use of BIC large-scale EDPE as compared with small or medium-scale EDPE used at each of the bases, and (2) the better system management made possible by this concept.

Non-electrical Communication

The most efficient method of sending data non-electrically is by postal service. The Air Force has tried using Log Air or a courier service, for example, and has found them too costly and too unreliable compared with the mails. Where the timeliness required of data is measured in days, however, air or first-class mail offers several advantages over electrical communications:

1. Mail is generally far cheaper;
2. The mails are very simple to use, i.e., there are no network problems; and
3. Data classified SECRET can be sent by registered mail.

As an example of non-electrical communication cost, we could assume an average volume of 4,000 base-BIC transactions per day for each of the 150 ZI bases to be serviced by the eight BIC's. The annual postage cost would be about $625,000 to send all these transactions on punched cards by first class mail. It is clear, however, that the actual system would have a mix of electrical and non-electrical communications, determined by volume, timeliness, and cost.

Electrical Communication

Electrical communication cannot be discussed comprehensively in general terms because of the many factors involved. Many electrical techniques are available which use different combinations of input-output media, modulation and demodulation techniques, transmission methods, and channel bandwidths.

The choice of an electrical technique, or more realistically, a set of techniques for a network which would be used to implement a data-flow system, depends on many considerations, including:

Location of communicating points
Volume per day
Peak rate
Security classification of data
Invulnerability
Batching
Time of day used
Days per month used
Input-output media
Relative priority of different types of data traffic
Accuracy and error checking
Message length

The above list is not exhaustive; only some of the more important aspects are listed.

For convenience, we classify communication as point-to-point if information is directly transmitted between a pair of communicating points, and as network-communication if it occurs among more than two points in a system.

Point-to-Point Communication

In order to give the reader some feeling for the speed and cost of electrical communication methods, several point-to-point techniques (teletype, Data Transceiver, Dataphone, Kineplex, etc.) have been selected for illustration. Assuming that transactions (each comprising 80 characters) are being transmitted directly from each base to its BIC by the above selected methods, the time required to transmit 4,000 transactions ranges from 0.7 to 6.7 hours; for 8,000 transactions the range is 1.4 to 13.4 hours. If similar methods were used continuously for eight hours, 4,800 to 100,000 transactions could be transmitted.

Large volumes of information can be transmitted on a point-to-point basis at reasonable cost.

Network Communications

Consider now a communication network which can use any of the above methods in conjunction with switching centers. For costing purposes we again assume a total communication load of 600,000 to 1,200,000 transactions per day for the 150 ZI bases. Many types of systems could be used in sending these transactions electrically, depending largely on other electrical communications requirements. As an example, an improved type of AMC Logistics Transceiver Network (LOGCOM), geared to base-BIC communication needs, would cost in the range of six to eight million dollars per year for the entire network in the continental United States. Since such a network could continue to serve many other needs, as does the present LOGCOM, only part of this cost would be applicable to the BIC system.

We wish to emphasize that networks capable of dealing with transaction volumes of 20,000 transactions or more per day per base can be established; the limitations faced are monetary rather than technical.

Conclusions

Electrical communication methods can be used to provide high-speed data flows at reasonable cost, and the implementation in the 1960's of a flexible, high-speed, high-capacity electrical network for logistics data communication is essential for the successful operation of a BIC system.[1]

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[1] See Section I for fuller discussion of need for high-speed communication.

ALTERNATIVE CENTRALIZED DATA PROCESSING POSTURES

Given the premise that many of the data processing functions presently accomplished at individual bases should be performed at a remote central location, there are several possible central processing systems of varying feasibility. The regional BIC is one. Another is a BIC for each of the major commands, which processes data for all logistics functions of that command's bases. A third possibility is the designation of an appropriate higher echelon to process a particular function for all Air Force bases.

Before discussing these systems, let us consider the several data processing echelons in the Air Force today. Data often travel from one echelon to another with consolidation sometimes occurring along the way. There are two reasons for this: (1) the existing chain-of-command concept, and (2) the past state-of-the-art of data processing equipment, which required the processing to be done at several echelons to prevent any one echelon from being overloaded with work.

With regard to (1) above, design of a comprehensive Air Force base data processing system through which a piece of paper moves must take into account whether the persons who get it really need to take any action on it or whether they rubber-stamp it "endorsed" and move it on. Paper should move through channels only for good reason.

With regard to (2) above, it is apparent that the state-of-the-art of data processing equipment is now so advanced that it is not necessary to delegate the processing to various echelons of command; by 1962, certainly, it should be possible to do the processing for 20 to 40 bases at one place.

For the sake of simplicity, we may categorize the three systems mentioned above as:

1. Regional Base Information Center
2. Command Base Information Center
3. Functional Center

These systems are distinguished by the fact that whereas a regional BIC would evaluate, interpret, and store information applicable to all functions at the bases in its region, a Command BIC would do so for all functions at all the bases in its Command. A Functional Center, on the other hand, would evaluate, interpret, and store information for all bases in the Air Force for the particular function at hand. Let us discuss several of the considerations relevant to each kind of center.

The BIC: Command or Regional

Throughout this paper we have discussed the BIC as though it were regionally oriented. The need for assuming a particular orientation was dictated by our desire to present some idea of the costs and other specifics involved. The concept of a BIC as a functionally integrated, geographically centralized data processing organization is, however, not materially affected by organizing it within a command structure or within a regional structure. In either case it would perform a substantial portion of the base data processing workload, efficiently store and make available to the base information necessary for base logistics management functions, and provide necessary reports and information to the operating and functional commands involved. We cannot overemphasize the importance of thus integrating these data processing functions, so that the impact of decisions in one area can be reflected in others.

The command BIC is, indeed, an interesting alternative to the regional BIC. It offers a posture whereby information which normally belongs in the

base-command information flow channel need not be diverted from that channel to a regional BIC and then returned after processing. Although AMC depots comprise most of the off-base points to which supply information is sent from bases or from which it is received, most other off-base information flows are concerned directly with operating command prerogatives and responsibilities and hence must tie bases to their respective operating commands. From this standpoint, and in view of the integration objective described previously, it is interesting to consider a posture involving one BIC (including the supply data processing function) at each of the major command headquarters.

There are, however, some problems associated with a command BIC, as compared with a regional BIC, which should be mentioned. The first is that of joint-tenant organizations on a base. At present, many bases house one or more tenant organizations from other commands. The long range tendency seems to be either to disperse to smaller and smaller units, to locate several very small units of a number of operating commands at a base actually identified with only one, or to do both. The problem of communication between each of these units and its operating command is far from trivial now and is likely to grow increasingly more severe. Its solution is not readily apparent. It may be that the command BIC, to which the base reports, can be equipped to process and store logistics data for each of the tenant units on that base. If this proves inadvisable, that BIC might act as a communications relay point between each tenant unit and its own operating command. Or finally, the communications network might be developed so as to connect each such unit directly with its own operating command.

At least two major problems arise with respect to communications. Both are largely cost problems and do not necessarily represent technological limitations. The first is the necessarily greater number of communications points in the command BIC posture, as suggested above. The second is the longer lines of communication implied by the same posture. To enable the BIC to function as a ready information repository for the base, we have assumed a direct communication link between each base and its BIC. If we are willing to relax this requirement and insert a switching center into this link, the communications problem of the command BIC is greatly eased. If we are not willing to do so, then the increase in communication costs may be as much as $15,000,000 per year if the problem of tenancy is ignored; and if the tenant units are also required to communicate directly with their own commands, then the communication costs may be substantially more.

We should also keep in mind that it is not necessary for all data to be communicated by electrical means. First class mail and airmail are very attractive for transmitting certain logistics information. The time lag introduced by mail communications in the command BIC posture is likely to be larger than that in the regional BIC situation, but the difference does not seem to be very significant.

The problem of triggering interbase shipments of materiel is facilitated by the geography of the regional BIC system but by the organization of the command BIC plan. It seems probable that the latter represents the greater advantage.

The Functional Center

The functional center (e.g., finance center, personnel center, supply center, etc.) maintains information on a single function for all bases in

the continental United States. Throughout this report we have stressed that many important interrelationships exist among these functional areas. (Figure 1 portrays some of them.)

Our purpose here is to specify a system which will reflect the impact of activities performed in one functional area on other functional areas. It seems clear that this would not be possible if separate functional data processing centers were established in lieu of BIC's. For these major reasons, the functional center has been identified as a relatively uninteresting alternative to the BIC and will not be dealt with in this report.

SUMMARIZED OBJECTIVES OF THE BIC SYSTEM

A base information center is intended to establish and maintain data files and process data for a set of bases. By doing so for all major base management functions, it will minimize duplication of filing and processing data and provide each functional element of management with pertinent information.

The additional communication costs required for the BIC system are more than offset by the savings possible through the efficiency of large-scale computers. At the same time, base management needs can be satisfied as expeditiously by BIC as it can by a data processing center at the base.

BIC, serving as a data processing organization for bases in the various major commands, will assist these commands in seeing that many of their directives are properly executed.

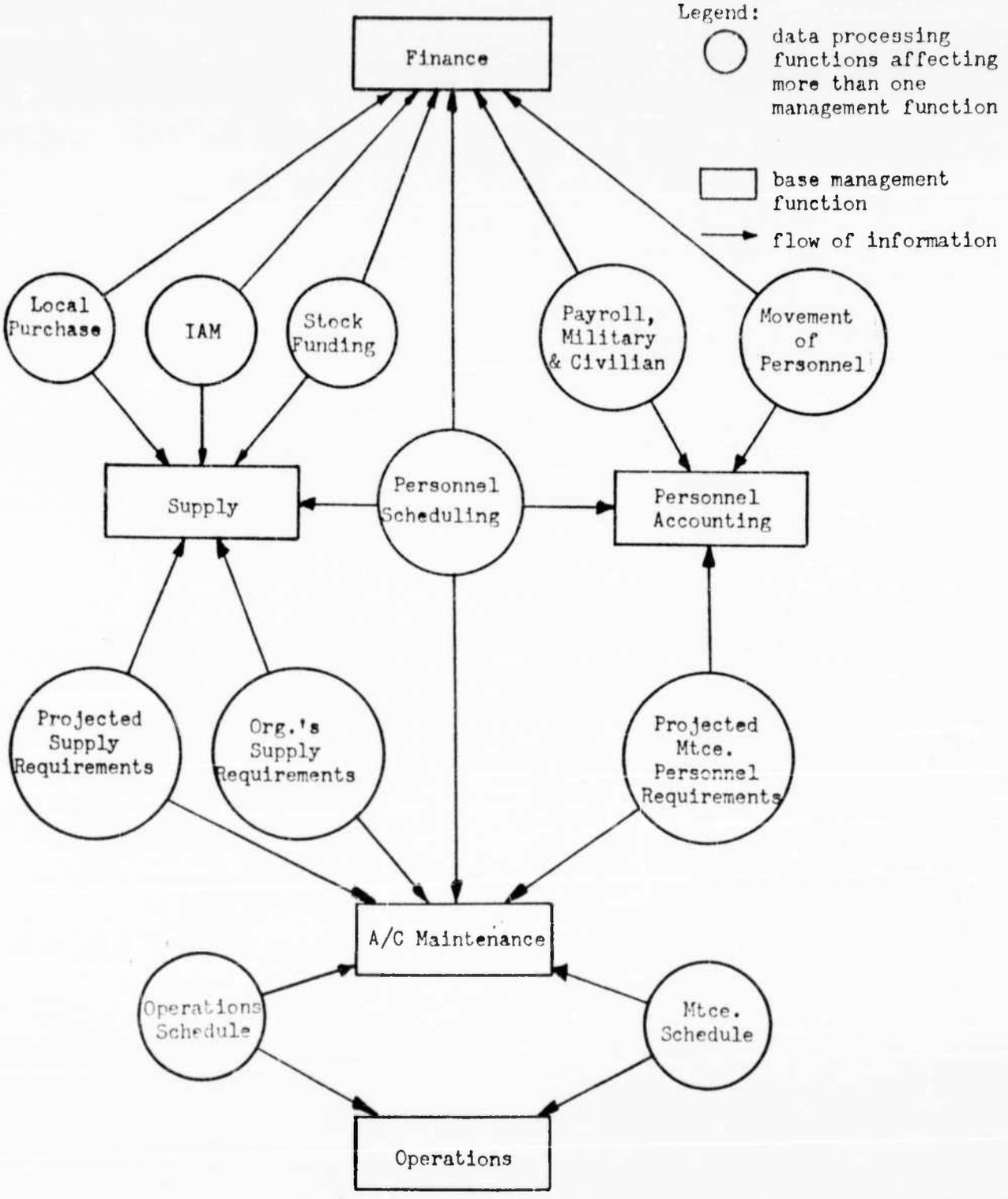

Figure 1--A SAMPLE OF FUNCTIONAL INTERRELATIONSHIPS AT A BASE

VI. RESULT PRESENTATION

An efficient system for Air Force base data processing will furnish information promptly at the time it is required for management decisions,[1] enabling the responsible manager to act judiciously without further need to process information or to compensate for its lack of timeliness. This section discusses the underlying considerations in the development of the result presentation phase of a new data processing system, including as it must the new capabilities in presentation available now and in the near future.

REPORTS CONTROL

The question of who gets what report, and how frequently, has always been a knotty one in large organizations. One reason for this is that management often initiates new reports without discontinuing old ones no longer required. A new manager coming into an organization, for example, is likely to feel that the reports initiated by his predecessors do not have all the information he needs. It is often easier for him to order additional reports and let the old ones continue as well, rather than to discontinue them. This is especially true if he is not the only one who gets them and if he assumes that the other recipients probably need the information on the old reports.

The Air Force has attacked this problem by establishing a reports-control group at each echelon of command. This group is charged with the responsibility to:

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[1] For an example of such a system and its theoretical background, see D. S. Stoller and R. L. Van Horn, Management Information for the Maintenance and Operation of the Strategic Missile Force, The RAND Corporation, Research Memorandum RM-2131, 30 April 1958. (For official use only; AFR 190-16.)

1. Check requested reports for possible duplication of established reports;

2. Help the initiator of the report to establish its form;

3. Help the initiator write the guiding directive to the units that will provide the report; and

4. Survey all reports periodically to determine if they are still needed or require amending.

This reports-control group can be strengthened by providing it with personnel experienced in the various functions, such as supply and personnel, who can question, on a technical basis, the need for much of the information in the report or even for the report itself; it will further be necessary to give this group the authority to exercise its control. In the future, when most of the information that management might request will be readily available from the EDPE, it would be particularly appropriate to include EDP system analysts in the reports-control group.

REPORTS IN A CENTRALIZED DATA PROCESSING SYSTEM

Reports of base activities serve one of the following purposes: (1) they provide helpful information for diagnosing management problem areas at a base, (2) notify management that its action is required, (3) enable management to plan future action, (4) exercise control of documents, and (5) satisfy legal requirements.

Reports for Management Diagnosis

Presently, the time lag between when a manager needs a particular piece of information and when the Statistical Service group can provide it is often so long that the information is worthless to him when he gets it. To protect himself, the manager generally requests a report containing this information monthly, weekly, and sometimes daily, even though he may need

the information only three or four times a year. With the advent of large-scale EDPE, which can accumulate and readily furnish information the manager may need, he will no longer need certain regularly scheduled reports. For example, Command Headquarters would require some of the information contained in the Base Supply Report[1] and other functional information only when the base appeared to be in trouble, as indicated by a high AOCP rate or a low number of training flights as compared with those of similar bases. In fact, computer programs can be written to compare performance information against standards specified by management, and automatically send reports to appropriate managers when minimum standards are not being satisfied.

Reports for Management Action

The manager should certainly receive reports that require his action. The action may be negative -- i.e., he may decide that nothing has to be done -- but such reports nevertheless reflect a situation that had to be brought to his attention.

Consider an example of this kind of report. If the funds for a particular base-budgeted project fall below a specified level, and there has been no automatic provision made for transferring funds from other sources, the EDP system could so notify the appropriate manager, give him other pertinent information (such as original allotment and uncommitted balance of funds that can be tapped) and thus permit him to take appropriate action. The system could also notify a base supply manager that materiel is being shipped

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[1] It is interesting to note that Headquarters USAF had been getting consolidations of the Base Supply Report from the major Commands, but recently directed that it no longer receive them. Amendment 62, Volume I, of AFM 67-1 no longer lists Headquarters USAF in the distribution.

to his base, and thus enable him to take such action as notifying the requesting organization and the warehouse manager.

Reports for Management Planning

The manager will also require reports that enable him to plan his future course of action. Information for this phase of his activity presently comes mostly from periodic reports. In the ultimate system, when many analytical computer programs have been developed, the periodicity of many of these reports will be eliminated and valuable analytic results will be provided the manager. For example, analysis of unfilled personnel authorizations may highlight unrealistic manning documents so that future planning can be improved. As another example, analysis of actual, as compared to predicted, demand rates for spare parts can help those preparing to provision for a new weapon comparable to a previous one.

Reports for Document Control

A fourth kind of report presently being transmitted is the control type, such as a voucher register or a daily transaction register. It is convenient, of course, for a base to receive a daily transaction register, and it is reassuring to the manager to see if all the transactions he sent to the remote data processing center have been received and processed; it may be possible, however, to achieve this checking feature at a much lower cost to the system. For example, the remote center could be required to send him a list of voucher numbers and document numbers (for non-vouchered items) against which he could check his own list, or, preferably, simply to perform this check automatically and report only the discrepancies. It is more convenient for the manager to check two lists of numbers, and still

more convenient to trace only the discrepancies, than to check a corresponding list of transactions. While redundancy for checking purposes is a requirement of current data processing, there should be little, if any, need to burden the manager with extraneous or redundant information for checking the system, as electronic data generation and processing become more reliable and self-checking.

Reports to Satisfy Legal Requirements

One class of reports stems from laws passed by Congress. For example, Congress has required that the three services maintain monetary inventory accounting, specifically stating that these systems should be in addition to quantitative property records.[1] This, of course, has resulted in reports by bases on monetary inventory accounting which go through channels up to Congress.

Some reports are used for legal purposes. An example of this is the morning report, which records actions of members of the unit; it may be required as evidence in courts-martial and claims against the government. The fact that the morning report is presently a legal document should not deter data processing systems analysts from developing a suitable substitute. In an automated data processing system, where the morning report may not be a suitable document, analysts must be free to develop appropriate documents that fit the system better and still satisfy legal requirements.

HARDWARE FOR RESULT PRESENTATION

The BIC will provide reports to the bases, the operating commands, and the functional commands, e.g., the AMC and the Finance Center. It is

[1]Public Law 216, 81st Congress.

important that these reports be presented in a manner convenient, timely and useful to them; equipment to do this is presently available or being developed.

The automatic quotation boards that show opening, closing, and last sale prices of stocks on the various exchanges are now in widespread commercial use. The fact that these boards can reflect rapidly changing situations suggests their potential use in Air Force applications.

Another kind of report, a graph, can be directly created by the computer. The computer can aggregate data over specified time periods and present it graphically by means of plotters connected to the computer.

Cathode ray tube display is still another tool available for presenting management with the information it needs. An accessory device can photograph the cathode ray tube display so that the manager can have a permanent record of the information.

Today the emphasis in output equipment is on the high-speed printers, which can print several thousand lines per minute. While we recognize the need for high-speed printers for certain projects, management will need them less and less as EDPE itself accomplishes more and more of the analysis. It cannot be stressed enough that a manager very often gets too much information rather than too little, with the result that he is unable to organize and use it. He will be able to function better if this information can be analyzed and directed toward a clear management purpose.

SUMMARIZED PRINCIPLES OF RESULT PRESENTATION

A reports-control group comprising functional and EDPE specialists should carefully investigate the requirements for reports in the BIC system.

Reports triggering managerial action should confine their content to that information relevant to management actions.

As data generation and processing become more reliable and self-checking, there should be little, if any, need to burden the manager with extraneous or redundant information for manually checking the system.

Finally, the EDPE should accomplish as much of the routine analysis as possible, leaving managers free to concentrate on more complex problems.

VII. DATA PROCESSING PERSONNEL AND MANNING

SPECIALIZED SKILL TRAINING

Personnel-training problems for the various operating-skill levels needed in data processing activities at all command levels fall into four major categories associated with:

1. Data generation and input to the system;
2. The automatic data processing phase;
3. Specialized training of non-data-processing management and operating personnel in using and interpreting the outputs of the system; and
4. Selection and training of data processing and management personnel in order to improve personal relations of all men working together.

Although it is obvious that these four categories are closely interrelated, we shall discuss them separately. The main reason for this separation is that these categories have received unequal emphasis in the past, and hence unequal changes in present Air Force policy are suggested.

Input Personnel

We have indicated previously that accurate and timely data input is the foundation of any effective automatic data processing system. Adequate procedures to insure that the data processed is accurate (and as complete as the system requires) and timely (minutes-old or days-old according to system needs) are absolutely essential.

Personnel and equipment concerned with the entry of data into the system are therefore assigned a difficult and important task. Elsewhere in this paper we have discussed the role of mechanization in easing this task and reducing personnel requirements. Let us now consider the role of the personnel who are still needed.

Until recently, there has been very little input activity in the base data processing structure. As we now begin to implement such an activity, and as its scope and necessary emphasis increase rapidly for the next few years, appropriate training and manning procedures must be developed and implemented.

The machines and techniques which we have described in a previous section must be employed by personnel completely familiar with their use and purpose. Equipment maintenance will be as necessary as that of a radar, fire control, or propulsion system. Although most automatic data input devices will be somewhat simpler than their airborne counterparts (exceptions will probably include coming developments in the field of automatic checkout equipment), a high level of technical knowledge will be required to understand their use and purpose.

For these reasons, personnel performing or responsible for data input will require extensive training. It will no longer be possible to entrust the job to personnel whose training is limited to aircraft equipment maintenance or warehousing, and who will not have a sufficient understanding of the importance of its accuracy and timeliness.

It has been pointed out that data should almost always be recorded manually only once, either by keying some device such as a typewriter or by recording it in handwritten machine-readable form. Consequently, we wish to emphasize that input action should become the basis for the entire system operation. As a direct or indirect by-product of this operation, all subsequent data flows and retranscriptions will be carried out automatically, both within the base and between bases and higher echelons. To the extent that this is true, the opportunity to check and recheck the

input data manually will no longer be available. While such a concept does indeed magnify those problems of accurate and timely data input which formerly seemed minor, the potential direct benefits from insuring accurate data input are very large.

Personnel in the Automatic Processing Phase

In contrast with current policies for lower echelon data input personnel, the Air Force policies for selecting personnel to man headquarters-level EDPE operations have recognized their highly technical nature. There is already reasonable emphasis at the level of computer programming and coding, and although Air Force data processing activities are not now staffed exclusively with experts, the trend seems definitely to be in that direction.

Two areas, however, have not yet received adequate emphasis: advanced computer programming techniques, and management of EDPE installations. As the Air Force increasingly uses EDPE, it will be necessary to train key personnel at each installation in optimal techniques for equipment usage. It has been amply demonstrated that the success or failure of an entire EDP installation can depend upon this single factor; therefore, it appears essential that such training should be augmented by several years experience in actual computer operations.

The personnel managing a computer installation will also require adequate training and experience before they can make proper decisions at a technical level. Week-long "executive" courses are entirely inadequate for this purpose. Experience as a programmer and coder, subsequent experience at the minor supervisory levels, and overall familiarity with computer operations, should be part of any truly optimum training plan for these

installation managers. While such a plan has not been feasible to date, it seems probable that only by its adoption can we achieve the enlightened management required in this field.

Training for Non-Data-Processing Management and Operating Personnel

Since an optimum system of data processing for Air Force bases probably would involve concepts presently foreign to the Air Force context for presenting the results of the processing phase, it seems clear that extensive training in the new purposes and methods of obtaining and using this information will be necessary. Such training for non-data-processing personnel, whose responsibility it will be to obtain and use this information, has not yet been initiated. Since this activity represents the fundamental purpose of the entire data processing cycle, its proper functioning cannot be left to chance.

Implementing the concepts described in this paper will sometimes lead to fundamentally different techniques for utilizing the outputs of the data processing system. Inquiries made directly to electronic files will replace foot-high reports on clerical desks; oral requests made to clerks just outside the manager's office will be replaced by requests for information from the computer system, entered at distances up to several hundred miles by the manager himself; and voluminous written or printed reports will be replaced by automatic displays at the key points where the output information is required.

Actual operation of these and similar devices will not be difficult. Usually, in fact, no real operation will be required—simply the knowledge of where to look on the output display or what button to push. It is in interpreting and utilizing these results that the problem arises. The

person who utilizes the information must know a good deal about the characteristics of each item of information involved: such as whether it is a day old or a minute old; whether, if the information is not sufficiently current, more up-to-the-minute information is available; and the type of information available by inquiry, as the need arises, in addition to that made available for decision as a matter of routine. Facility in interpreting and utilizing such information will come with increased experience, but can be rapidly accelerated with suitable training.

An Illustrative Example

To give the reader some idea as to what can result when personnel are inadequately trained or skilled in EDPE, we describe an actual occurrence. It deals with an inventory control application in which indicative information and current stock balances pertaining to about 50,000 different inventory items were maintained in the electronic files of an automatic data processing machine. The machine's analysis of these files revealed that a substantial number of the items were no longer required at the geographical point for which the machine was keeping records. This fact was duly relayed to higher management.

In accordance with good inventory principles, management decided that the superfluous items should be removed from the warehouses at this inventory point and the records purged from the machine. Machine personnel went to work immediately and entered the necessary information into the machine to effect the stock transfer. The machine, under control of its program, prepared shipping orders for each of the items designated so as to wipe out the stock on hand. The items were shipped forthwith.

Having accomplished the job they set out to do, the data processing and associated units then told the machine to purge the obsolete records from the machine. It soon came to their attention, however, that the machine would not remove the obsolete records from the file since a "due-in" balance had been established for each of the items in question.

The machine, following the program exactly, had noted that the stock balance of each of the items had fallen below the reorder point (in fact, to zero) when the shipments had occurred, had initiated a requisition to replenish the stock, and had thus created a due-in balance for each item. The personnel had failed to accomplish the task of reducing the reorder point to a negative quantity before issuing the shipping directions.

We will not comment on this illustration other than to remark that the machine did exactly what it was instructed to do, and no fault whatever can be found with its operation. The personnel involved, however, failed to perform their proper functions with respect to an automatic data processing system.

PERSONALITY CONSIDERATIONS

Recent psychological studies have measured the great impact of personality factors on the efficiency and productivity of two or more persons working together.[1] These studies demonstrate the profound effect, on group output, of the ability of people to get along personally and to work out a satisfactory method for decision-making.

This problem seems to be especially acute in the data processing area because of the relative lack of concrete objectives and the relatively large

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[1]See W. C. Schutz, FIRO: A Three-Dimensional Theory of Interpersonal Behavior, Rinehart & Company, Inc., New York, 1958.

dependence on subjective attitudes of people. Thus, while the effectiveness of any data processing system is limited just as in any system, by the intellectual capacities of individual men, it is further and perhaps more decisively limited by the personal interrelationships within the data processing complex, or between data processing personnel and those in such areas as maintenance, finance, and supply.

Two areas of this problem are potentially fruitful for applications of psychological research: (1) initial composition of work groups and (2) personnel training in social relations. Techniques have been devised and experimentally validated that allow for the prediction, based on the initial testing of individuals, of how they will interact socially with others in a work situation. This procedure, adapted to data processing groups at their initial composition, could significantly increase the general level of personnel compatibility -- and hence productivity -- over that of a group formed without considering personality traits.

In addition to improving the initial composition of groups, explicit training in human relations will improve these personal relationships. Industrial, governmental, military, and academic circles have recently shown great interest in and success with such training. In this process a trainer conducts a series of sessions with the working personnel in order to help them gain insight into themselves and their relations with others, and utilize it to improve the working relations of the group. This training, supplementary to that in the initial composition of groups, has demonstrated its effectiveness in almost every application. It has also proved helpful in situations where it is not feasible to preselect only compatible personalities who are to work together.

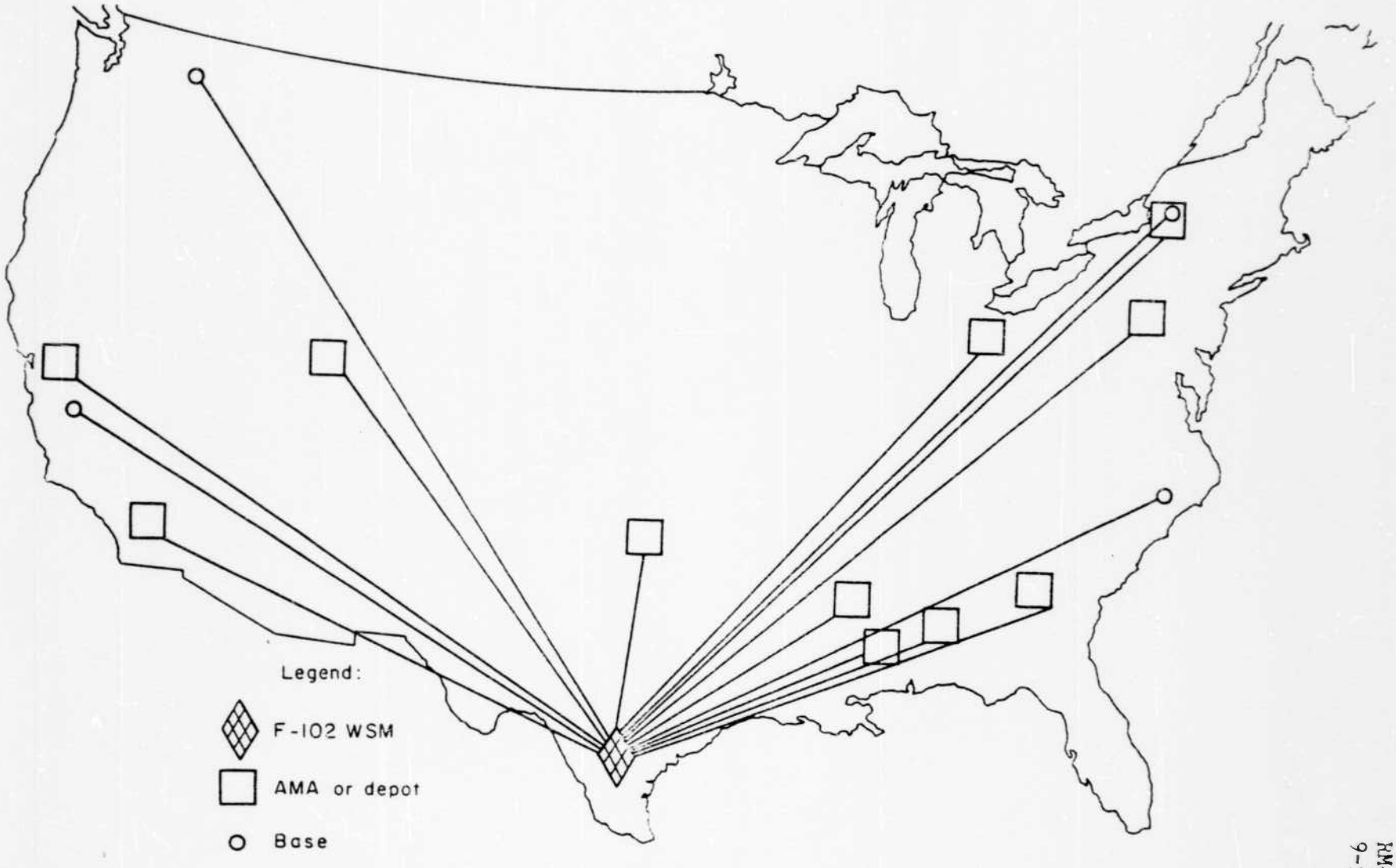
REVIEW OF THE ROLE OF PERSONNEL FACTORS IN EDP SYSTEMS

New techniques and devices for reflecting events in a form useful in an automatic data processing system, digital computer and information storage and retrieval systems for processing and storing those data, and new methods and equipments for the presentation of processed results to all levels of management, create the need for a substantial amount of additional data processing training for the personnel involved. The highly subjective nature of the development of these systems and techniques suggests the need for special emphasis on personality considerations in this development. Their operational use will require specialized training, not only in the input, processing, and output phases of data processing, but in the understanding of the new data processing system by the non-data processing people whom it serves.

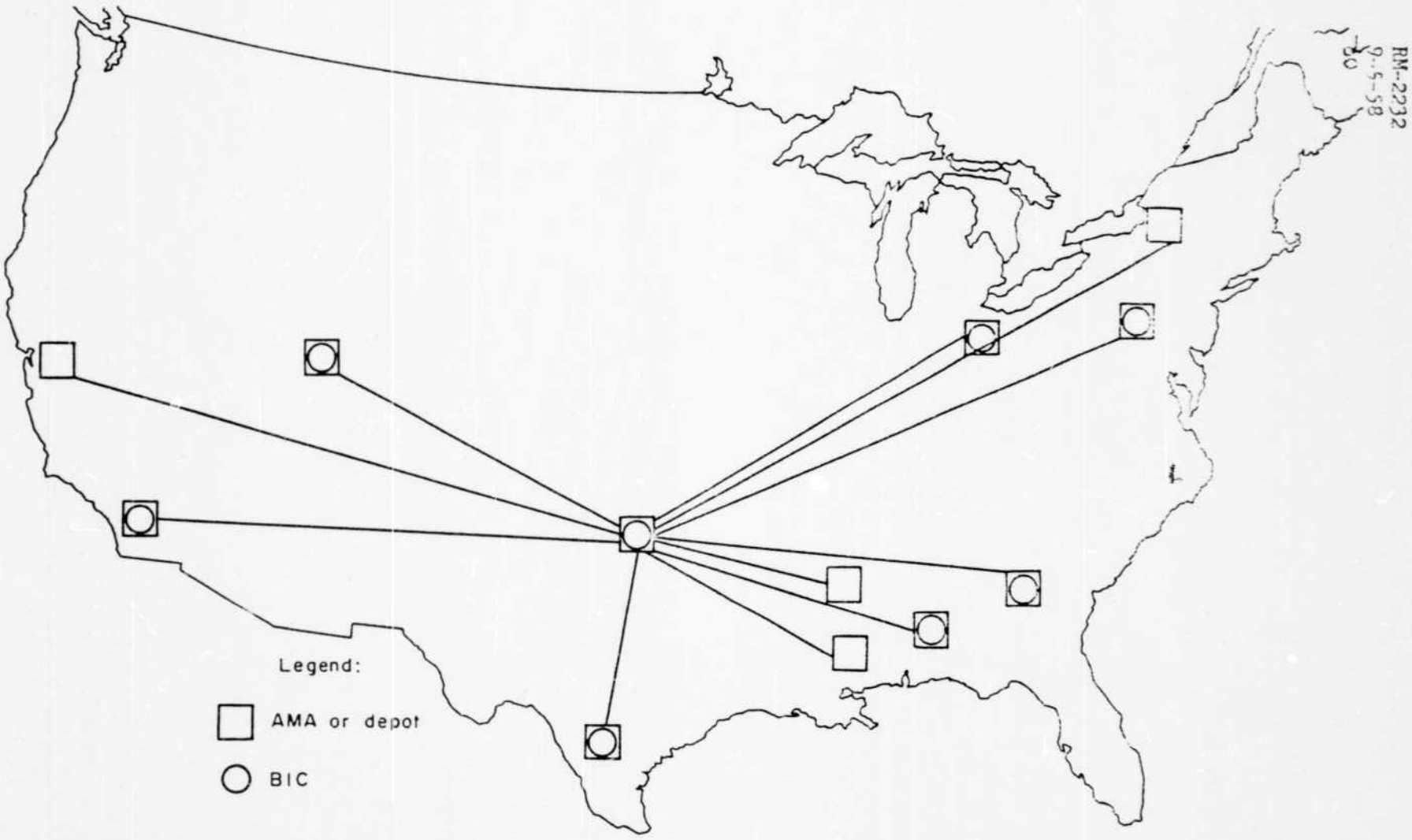
VIII. CONCLUSIONS

This paper concludes that it will be necessary and desirable, in the next few years, to carry out the major portion of the data processing for the Air Force base complex in the continental United States at several central organizations established for the purpose and remote from the bases themselves. Such a step appears necessary to cope with the increasing dispersal of operating units and the growing complexity of scientific management techniques.

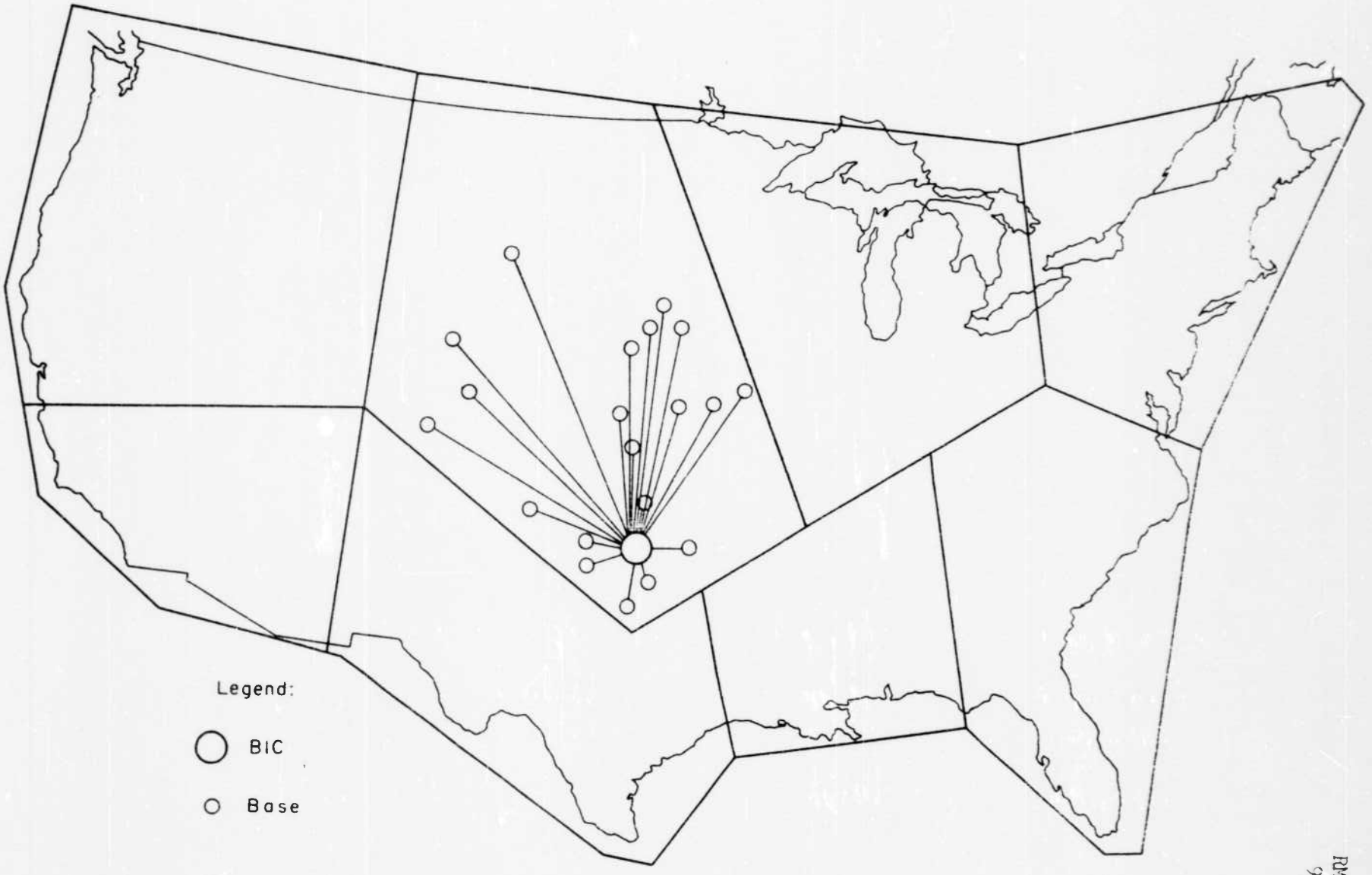
We further conclude that it will be necessary and desirable to increase substantially the effort to introduce semi-automatic or automatic techniques for data introduction and report generation, wherever data are generated or reported. By making these activities automatic and thereby minimizing human intervention in the data processing activities, increased accuracy and confidence in the results can be gained. Fewer people operating more powerful automatic equipment can conceivably make errors of large magnitude; the prevention of such errors requires serious attention through checks, careful training, and observation of computer operations. By thus providing a sound basis for decision, the scientific management and data processing equipment tools which are at our disposal can be effectively utilized.



Appendix A — Weapon system information flow for the F-102



Appendix B — Regional BIC-AMA information flow



Appendix C — Base - Regional BIC information flow

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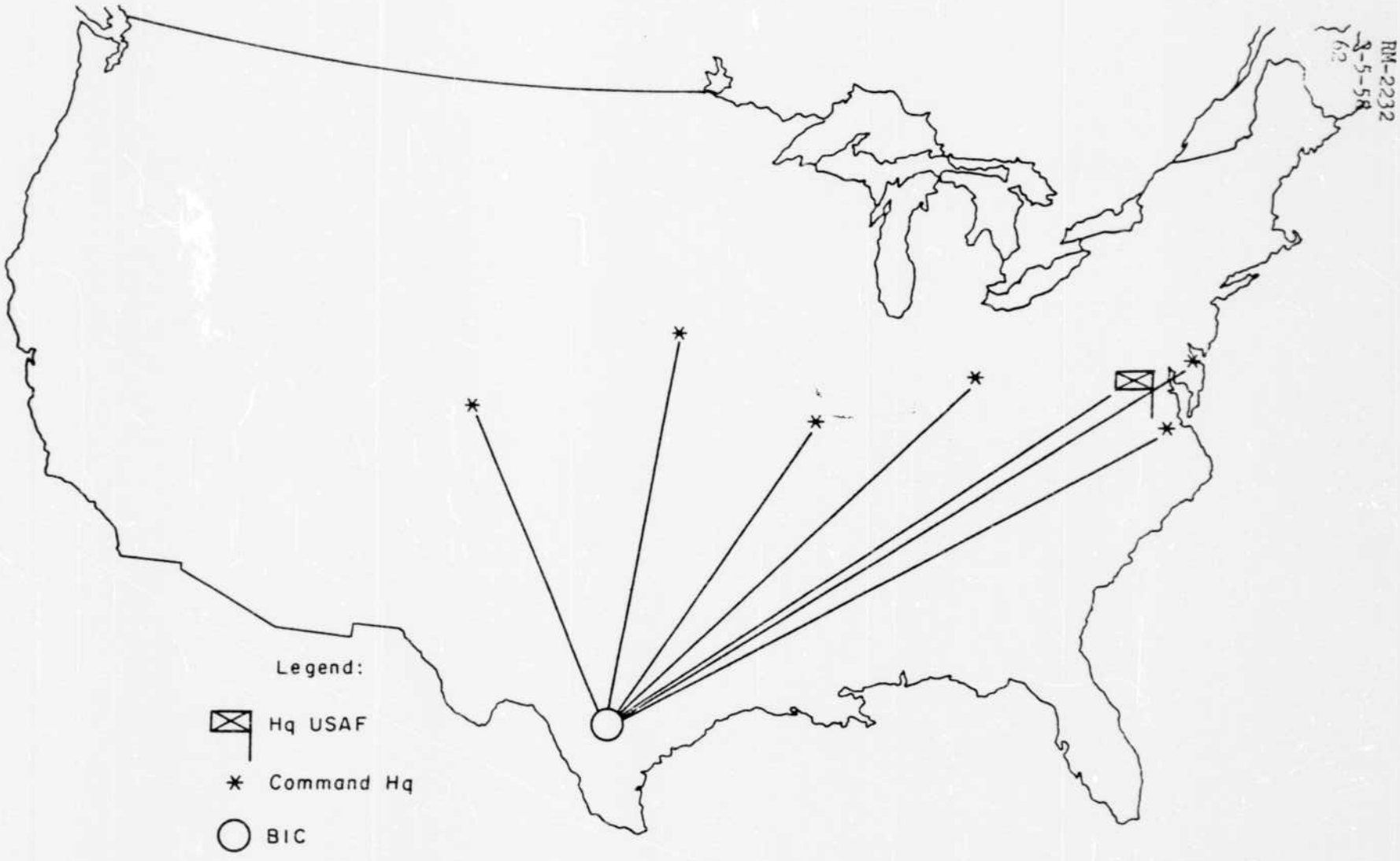
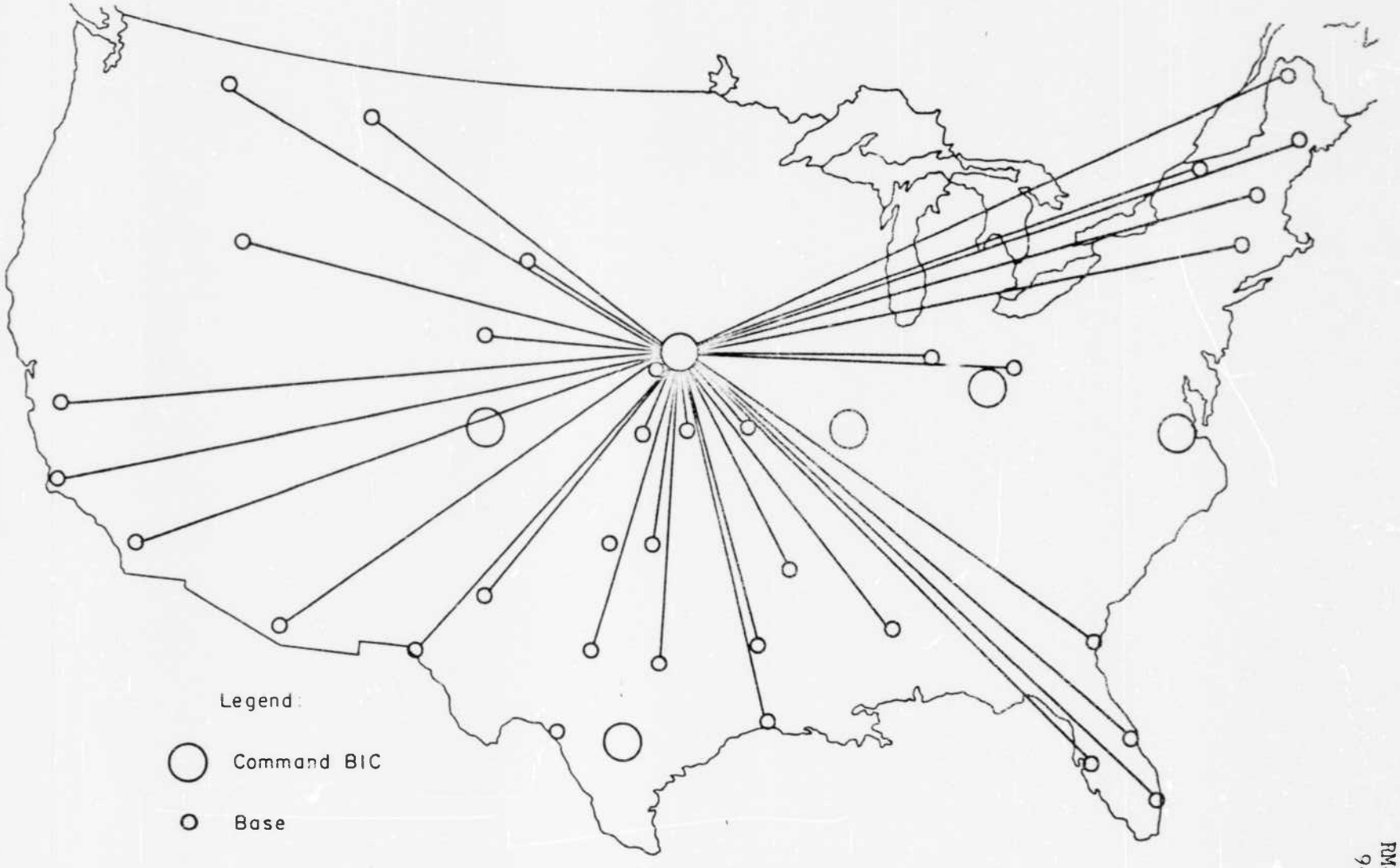


Appendix D — Regional BIC, Command, and HQ USAF information flow



Appendix E — Base - Command BIC information flow